PARASITES OF THE COMMERCIAL SHRIMPS, *PENAEUS AZTECUS* IVES, *P. DUORARUM* BURKENROAD AND *P. SETIFERUS* (LINNAEUS)[1,2]

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Introduction

The U. S. Fish and Wildlife Service Fishery Statistics of the United States for 1956 show that shrimp are by far the leading seafood industry in the United States. The total catch for 1956 was worth $70,894,000. The Gulf of Mexico produced $62,499,000 of this amount. Though the importance of shrimp in the fishing economy has been increasing steadily since 1956, little is known about their parasites. Knowledge concerning deleterious effects, distribution and host specificity of shrimp parasites is desirable for both academic and economic interests.

The specific goals of this preliminary survey were: (1) description and identification of the parasites of *P. aztecus, P. duorarum* and *P. setiferus* from Alligator Harbor and Apalachicola Bay, Florida; (2) determination of the incidence and site of infection of these parasites; and (3) recording observations regarding host specificity and life histories of these parasites.

After the present paper had been submitted for publication Hutton, *et al* (1959) published a preliminary report dealing with parasites of shrimp in Florida waters. For a historical review of the subject the reader is referred to this work.

Materials and Methods

Collection of Hosts

The shrimp hosts, *Penaeus duorarum, P. aztecus* and *P. setiferus,* were collected from three locations along the northwest Gulf coast of Florida between June and November, 1958. Most *P. duorarum* were collected at approximately monthly intervals from July through October in Alligator Harbor, Franklin County, Florida. These shrimp were collected in the grassy flats on the sand bar in the mouth of the harbor with either a push net or a small beam trawl. One collection of ten specimens of *P. duorarum* was made in Apalachicola Bay, Franklin County, Florida in October; another collection of four shrimp was made in the grassy flats near the mouth of the St. Marks River, Wakulla County, Florida in September. All specimens of *P. aztecus* and *P. setiferus* examined were collected from Apalachicola Bay with a large shrimp trawl. The collections were made at seven different stations in the bay that varied from shallow grassy flats near its head to a depth of 40 feet near St. George's Island. *P. aztecus* and *P. setiferus* were collected at approximately monthly intervals from June through October. The shrimp were identified with the aid of the keys to the family Penaeidae by Anderson and Linder (1934) and Voss (1955).

Examination of Hosts

All of the shrimp caught were macroscopically examined for evidence of a microsporidian infection locally known as "cotton shrimp", "blue shrimp" or "milk shrimp". The incidence of this infection in relation to the total catch was noted. The infected specimens were either preserved in 10% formalin or brought back alive to the laboratory at Florida State University for further study. A representive sample of normal "non-cotton shrimp" was taken from each station; these were transported alive in three gallon glass jars to the laboratory for complete examination.

The shrimp were dissected alive in petri dishes in a small amount of sea water or physiological saline. Hosts which had been iced or preserved in formalin proved to be unsatisfatcory for examination. The digestive gland in iced shrimp liquefies rapidly and fills the hemocoel with cytolized yellow tissue making small translucent parasites

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[1] A portion of a thesis submitted to the graduate Council of Florida State University in partial fulfillment of the requirements for the degree of Master of Science.

[2] A contribution from the Department of Biological Sciences and the Oceanographic Institute (No. 120), Florida State University.

difficult to find or to determine their natural position in the host. The smaller parasites in preserved shrimp are difficult to detect due to the lack of movement. Also the parasites, especially the gregarines, in the gut and digestive gland deteriorate rapidly. In order to fix the parasites in good condition one should cut open the shrimp in the field before preserving. Tissues of the shrimp studied were teased apart and examined with a dissecting microscope. The intestines were cut open, placed on a microscope slide, covered with a coverslip, and examined with a compound microscope.

Details of methods will be given with the descriptions of individual parasites. All measurements are in millimeters unless stated otherwise; averages usually precede the ranges in parentheses. All illustrations were made from living specimens unless stated otherwise and were drawn with the aid of a microprojector or camera lucida.

Observations

Subphylum Sporozoa Leuckart, 1897
Class Telosporidea Schaudinn, 1900
Order Gregarinida Lankester, 1866
Suborder Eugregarinia Doflein, 1901
Tribe Cephalina Delage and Hérouard, 1896

Cephalolobus penaeus, gen. nov., sp. nov.

(Figures 1-5)

These gregarines were first studied alive in their natural habitat by removing the stomach and mounting the entire structure on a glass slide in physiological saline. The specimens were then fixed in AFA and mounted in Damar without staining. A few gregarines were stained with Ehrlich's acid hematoxylin. All measurements are in microns and were made from 20 living specimens.

Description. — Trophozoites divided into protomerite and deutomerite by ectoplasmic septum; young, solitary trophozoites up to 171 long by 45 wide, protomerite 46 long, deutomerite 125 long. Trophozoite associations 328 to 660 long by 66 to 125 wide; primite 118 to 231 long by 66 to 158 wide, usually wider than satellite, protomerite of primite 33 to 85 long, deutomerite 99 to 198 long. Satellite 211 to 429 long by 33 to 118 wide; protomerite of satellite 26 to 52 long, deutomerite 211 to 376 long. No true epimerite observed; anterior end of protomerite modified into holdfast, consisting of sub-cylindrical cone with 15 to 40 irregular lobe-like processes around edge. Holdfast region in mature associative trophozoites usually set off by a constriction from rest of protomerite; holdfast used to attach young individuals and mature associative trophozoites to chitinous sheet between ventral surface of the base of the terminal lappets and the filter. Primite of many individuals bent at about 45 degree angle. Usually one satellite attached to primite, sometimes two or three satellites; protomerite of satellite with no special lobed holdfast (anterior surface of protomerite of dislodged satellite only slightly irregular). Endoplasm in deutomerite of primite and satellite more densely granular than that in protomerite of primite and satellite. Ectoplasm a thick, hyaline layer around periphery of organism and on both sides of ectoplasmic membrane that separates protomerite from deutomerite. Nucleus 33 to 56, in deutomerite only, containing 3 to 12 sperical granules. Single individuals and those in association capable of locomotion when dislodged from chitinous sheet. Spores, sporozoites, free sporonts and cysts not observed.

Hosts.—Penaeus aztecus and *P. duorarum.*

Location.—Young individual and mature associative trophozoites attached to chitinous sheet that extends from ventral surface of the base of the terminal lappets to the filter of the stomach.

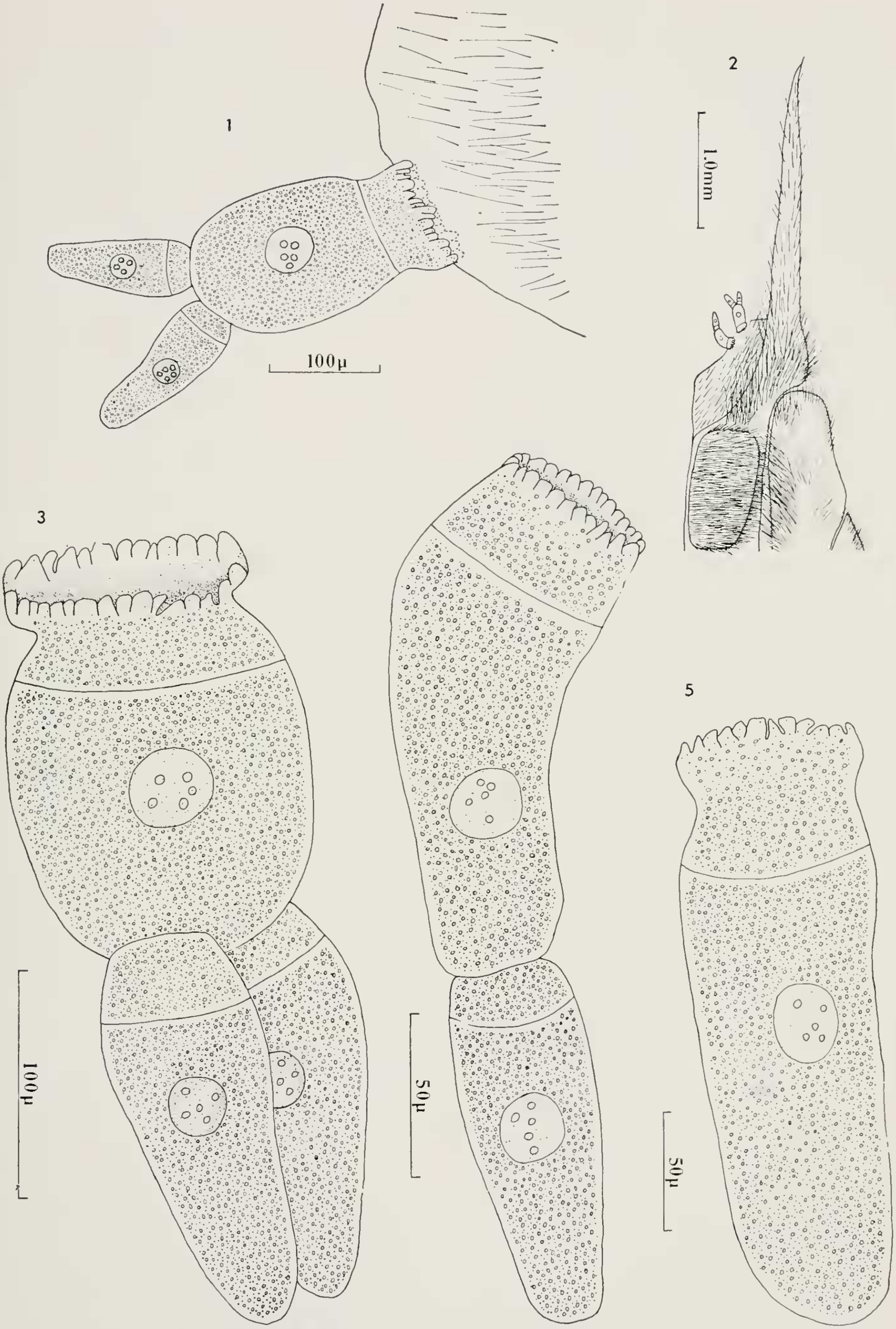
Locality.—Northern Gulf coast of Florida.

Types.—Holotype and paratypes in Helminthological Collection of the Department Biological Sciences, Florida State University.

Generic diagnosis of Cephalolobus. — Young individual and mature associative trophozoites septate, trophozoites associative and mature while attached in gut of host; one, two or three satellites in syzygy with primite, syzygy caudofrontal, satellite smaller than primite; development extracellular; true epimerite absent, anterior end of protomerite modified into holdfast consisting of sub-cylindrical cone with irregular lobe-like processes on anterior edge; protomerite of satellite without specialized holdfast. In gut of marine decapods.

Type species.—Cephalolobus penaeus.

The trophozoites of *C. penaeus* were



Figures 1-5. *Cephalolobus penaeus*, gen. nov., sp. nov. **1, 2.** Illustrations showing the method and place of attachment of the organisms on the thin chitinous sheet between base of the lappet and filter. **3.** A multiple association with one primite and two satellites; note constriction of the protomerite which sets off the holdfast. **4.** The most common type of association with one primite and satellite. **5.** A solitary trophozoite.

found in 26 or 15.2 percent of 170 shrimp examined. Eleven or 17.7 percent of 62 *P. aztecus* were infected with an average of 7.7 trophozoites per shrimp whereas 15 or 20.8 percent of 72 *P. duorarum* were infected with an average of 4.5 trophozoites per host. The number of trophozoites per shrimp ranged from one to 21. The 36 *P. setiferus* examined were all found to be negative.

Only one other genus, *Anisolobus* Vincent 1924, has been reported as lacking an epimerite and having the anterior end of the protomerite developed into a lobed holdfast. The genus *Cephalolobus* differs from *Anisolobus* in the following points: (1) The protomerite of *Anisolobus* is expanded considerably to form a few large, flat lobes which function as a sucker-like organ for attachment of the trophozoite to the cells of the host's gut wall; the protomerite of *Cephalolobus* is not expanded but is a subcylindrical cone and is composed of many digitform lobes that attach the trophozoite by holding the thin chitinous sheet of the stomach between the lobes; (2) The very young trophozoites of *Cephalolobus* have the special holdfast whereas the young of *Anisolobus* do not; (3) *Cephalolobus* occurs in syzygy while in the attached trophozoite stage; *Anisolobus* occurs in syzygy only in the free sporont stage; (4) Sporadins of *Anisolobus* are biassociative; the primite of *Cephalolobus* may have one, two, or three satellites; (5) The host of *Anisolobus* is a coleopteran whereas *Cephalolobus* parasitizes a marine decapod.

Cephalolobus penaeus also differs from most gregarines in being attached to a thin chitinous sheet from the very young stages to mature associations and thus presumably obtains all of its nourishment by absorbing through its body wall food in the host's stomach. An epimerite in the young stages of most gregarines remains inside the host's gut cell and serves for attachment and absorption of the cell contents for food. These gregarines lose their epimerites, then mature and become associative while free in the host's gut where they presumably absorb food through their body surfaces.

The nature of the holdfast prevents assigning *Cephalolobus* to a family at the present time; however, it is most similar to members of the family Gregarinidae Labbé, 1899. Kamm (1922), Grassé (1953) and Kudo (1954) stated that the presence of a simple knob-like epimerite is one of the characters of the family Gregarinidae; *Cephalolobus* and *Anisolobus*. therefore, do not belong in the family. If the life cycle of *C. penaeus* is proven to be similar to that of *Anisolobus,* both genera should be placed in a new family.

Cephalolobus is somewhat similar to members of the family Dactylophoridae Léger, 1892 except that the dactylophorids are solitary and they are described as having an epimerite. However, Grassé (1953) believed that the true epimerite is replaced in the young stages with protomerite extensions, and that the complex holdfasts of the dactylophorids are not epimerites but actually modifications of the protomerite. This may be what occurs in *Cephalolobus*.

Family Porosporidae Léger, 1899
Nematopsis penaeus Sprague, 1954
(Figures 6-13)

The sporonts were removed from the lumen of the intestine with a needle, placed in sea water on a glass slide and studied alive under the microscope. Young trophozoites were observed by removing the entire intestine, cutting it lengthwise, flattening it on a slide, teasing it apart and then flattening it slightly with cover glass pressure. Gametocysts were removed from the wall of the rectum and studied alive. Gymnospores were liberated from gametocysts by slight cover glass pressure which broke the cyst wall. Some of the gymnospores were stained with Ehrlich's acid hematoxylin. All measurements are in microns and were taken from 35 to 50 living specimens.

It is the author's opinion that this species is *N. penaeus* Sprague, 1954 in the family Porosporidae Léger; although, as Sprague, (1954: 249) indicated, definite generic determination cannot be made until stages in the intermediate host are known, since it is on the basis of these that the genera (*Porospora* Schneider and *Nematopsis* Schneider) in the family Porosporidae are differentiated. Sprague described *N. penaeus* from *P. aztecus* collected off the Louisiana coast and he also found what seemed to be the same species in *P. setiferus*. Sprague's description did not include illustrations.

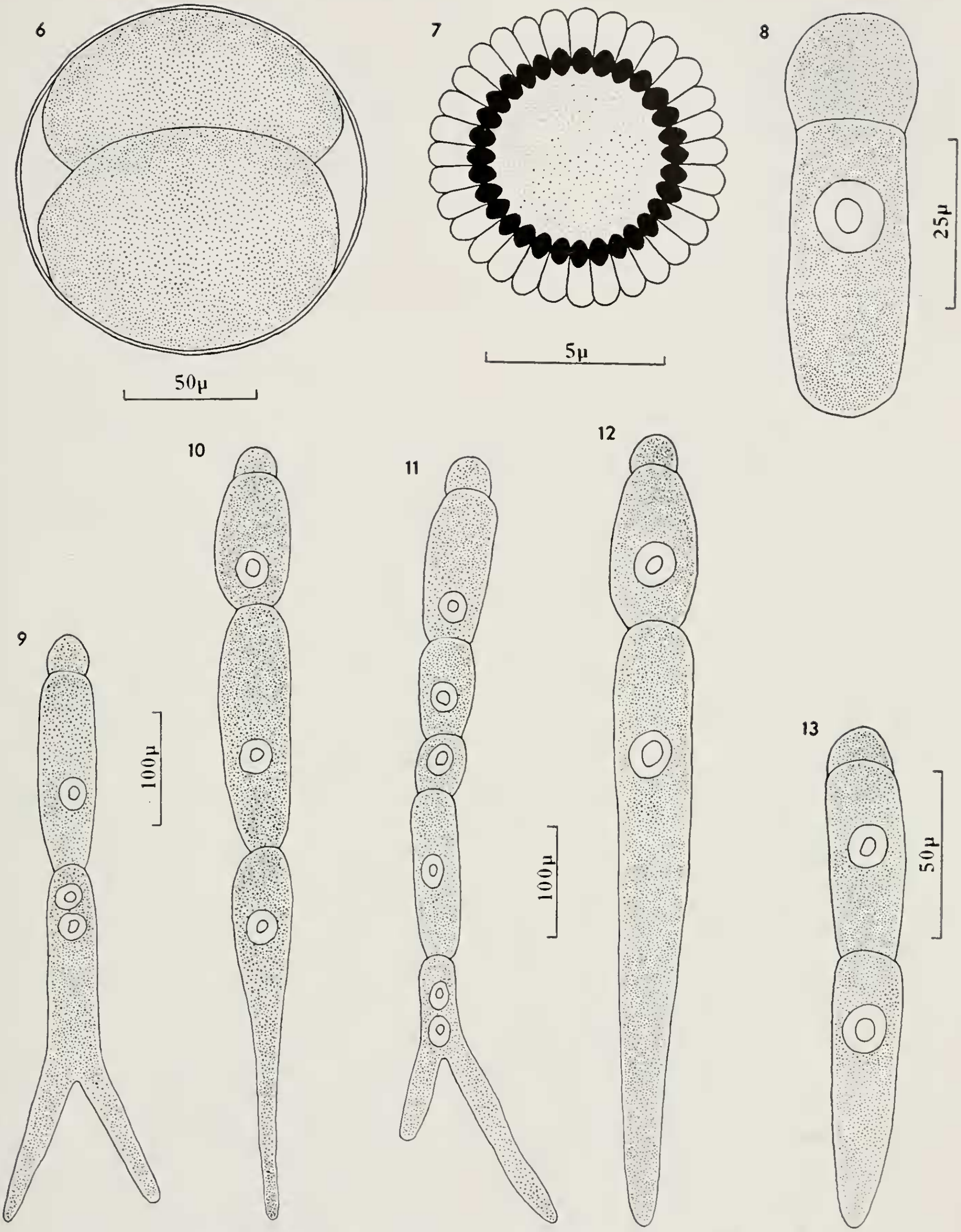


Figure 6-13. *Nematopsis penaeus* Sprague. **6**. Young gametocyst. **7**. Mature gymnospore; drawn from preserved material. **8**. Solitary sporont. **9-13**. Mature sporonts showing various types of bifurcated and linear syzygy.

The data and illustrations here supplement Sprague's account.

Description. — Young trophozoites attached to intestinal cells by simple, spherical, epimerite; solitary sporadins up to 70 long by 19 wide. Older sporadins in multiple linear and bifurcated syzygy. Ectoplasmic wall disappears between protomerite and deutomerite of satellites. In bifurcated syzygy nuclei of both individuals move to stem portion. Smallest biassociation 120 long by 26 wide; multiple associations up to 590 long by 40 wide. Up to five individuals in linear syzygy. Gametocysts spherical, attached to wall of rectum, 158 (99-240) in diameter; mature spherical gymnospores 6.5 (6.3-9.8) in diameter.

Hosts.—*Penaeus aztecus, P. duorarum* and *P. setiferus.*

Location.—Young forms attached to cells of intestinal wall, sporonts and associations free in lumen of intestine, gametocysts attached to wall of entire length of rectum.

Locality.—Alligator Harbor and Apalachicola Bay, Florida.

At least one stage (young trophozoite, sporont or gametocyst) was present in all of the approximately 60 shrimp that the author examined thoroughly. All three stages were usually present in most individuals of all three species of shrimp; however, in some shrimp only the very young trophozoites or mature gametocysts could be found.

Sprague (1954) discussed the comparisons and affinities of *N. penaeus* with other members of the family Porosporidae. He also presented evidence that *N. penaeus* has an intermediate host in its life cycle as do *N. ostrearum* and *N. prytherchi.* This idea has been substantiated by the writer's work. Shrimp kept in laboratory aquaria for a week or longer lose infections of *N. penaeus* even if they live in close association with each other and are fed infected shrimp. This suggests that the spores from the gymnospores must undergo development in an intermediate host before they are infective for the shrimp. The intermediate host must be some organism that the shrimp feed on frequently, because in nature the shrimp are usually heavily infected with young and older stages, and the parasite does not reproduce while inside the shrimp host.

Class Cnidosporidea Doflein, 1901
Order Microsporidia Balbiani, 1883
Family Nosematidae Labbé, 1899
Thelohania sp.
(Figures 14-20)

This species was studied alive with the phase contrast microscope and in fixed smears and sections. Smears, and cross and longitudinal sections of infected abdominal muscles were fixed in Bouin's and stained with Erhlich's acid hematoxylin. Extrusion of polar filaments was accomplished by exerting cover glass pressure on live specimens. All measurements are in microns and were taken from 30 living specimens.

Description. — Preponderance of mature pansporoblasts with eight spores in living muscle smears; pansporoblasts spherical with thin, clear limiting membranes through which spores are visible; mature pansporoblasts 10.2 (8.8-13.6) in diameter; spores in mature pansporoblasts 5.4 (6.4-4.0) long by 3.4 (3.0-4.0) wide, highly refractile with large vacuole at one end. Free, solitary spores 5.7 (6.1-4.7) long by 3.7 (3.0-4.0) wide, posterior end slightly wider than anterior end, with large posterior vacuole. Polar filament extruded from anterior end 109 (97-142) long, almost uniform in width for entire length, tapering slightly at distal end.

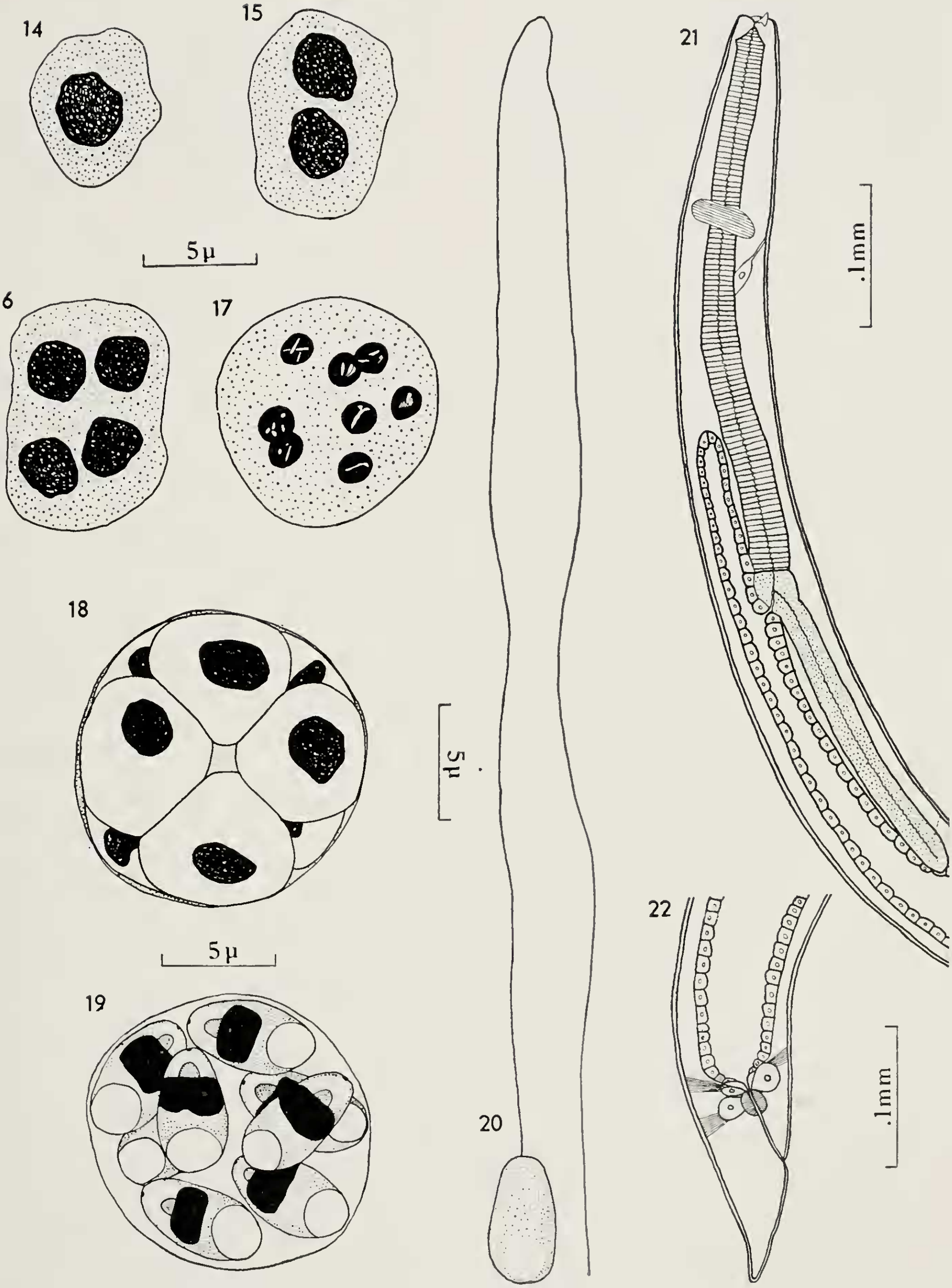
In stained smears structure of the sporonts and spores visible in more detail. Young developing sporonts with 1, 2, 4 or 8 darkly stained nuclei, cytoplasm light and finely granular. Eight nucleated stage followed by partitioning of cytoplasm into eight sections with a nucleus in each section destined to form a spore; this developmental stage of pansporoblast slightly larger in diameter than mature pansporoblast. Stained free spores with large clear vacuole at posterior end and smaller clear area at anterior end; darkly stained nucleus near middle, almost as wide as spore; lighter grey cone-shaped polar capsule projecting from nuclear area toward anterior end; anterior tip of polar capsule darkly stained at opening, remaining portion of spore stained a homogeneous light blue color.

Hosts.—*Penaeus aztecus, P. duorarum* and *P. setiferus.*

Location.—Mainly in muscles but also in other organs.

Locality.—Alligator Harbor and Apalachicola Bay, Florida.

The musculature of "cotton shrimp" is white with intermingled blue-black areas and lacks the firmness of normal muscle. Of the 4816 examined, 553 (11 percent) were grossly identifiable as infected. The incidence of infection in each host species was as follows: *P. aztecus,* 310 (16 percent) of 1874 examined; *P. duorarum,* 15 (1.9 percent) of 784; *P. setiferus,* 228 (10 percent) of 2158. *P. duorarum* had the low-



Figures 14-22. All figures drawn from preserved material except fig. 20. **14-20.** *Thelohania* sp. **14-17.** 1-, 2-, 4-, and 8-nucleated developing sporonts. **18.** Developing pansporoblast. **19.** Mature pansporoblast. **20.** Living free spore with polar filament extruded. **21-22.** Juvenile of *Contracaecum* sp. showing anterior and posterior ends.

est incidence of infection probably because the specimens examined were much younger than those of *P. aztecus* and *P. setiferus*. These figures obviously do not represent the true incidence of infection because the early and light infections cannot be detected with the unaided eye; in fact, the writer noted many such light infections during dissection of shrimp under the microscope.

In a heavy infection most of the muscles and other organs of the body were parasitized. Histological sections showed that the organisms saturate the muscle tissue, lying in large sheets or masses in and around the muscle fibers. Apparently all stages of development take place in the muscles.

A satisfactory specific identification of this microsporidian cannot be made until it can be compared with *Thelohania penaei* Sprague, 1950, *T. hunterae* Jones, 1958, and *T. duorara* Iversen and Manning (in press). Sprague did not give a detailed description of *T. penaei* which he found in the gonads of *P. setiferus* collected in the vicinity of Grand Isle, Louisiana. According to his description *T. penaei* differs from the present species in the following ways: (1) The spores of *T. penaei* average 4 by 2.2 whereas spores of the organism herein reported average 5.7 by 3.7; (2) The polar filament of *T. penaei* averages 70 long and has a thick proximal half with a thinner distal half; the polar filament of the present species averages 109 long and is essentially uniform in diameter for its entire length; (3) *T. penaei* was found in the gonads only; the present one is mainly in the muscles.

Jones' (1958) report on *T. hunterae* is an abstract (according to a personal communication he has a detailed paper in press) and has very little information. *T. hunterae* is described as primarily a coelozoic parasite which sometimes invades the ovary and nerve cord, while the present specimens were found mainly in the muscles.

Iversen and Manning permitted the author to re?d a paper by them (in press) describing *Thelohania duorara* from the musculature of *P. duorarum* collected from Biscayne Bay, Florida Bay and the Dry Tortguas region, Florida. Their description of *T. duorara* agrees well with the author's specimens except for polar filament length. The polar filament of *T. duorara* averages 38 in length whereas the polar filament of the present specimens average 109.

Class Trematoda Rudolphi, 1809
Order Plagiorchiida La Rue, 1957
Family Opecoelidae Ozaki, 1925
Metacercaria of *Opecoeloides fimbriatus* (Linton, 1934) Sogandares-Bernal and Hutton
(Figures 23-27)

Synonymy.—Distomum vitellosum Linton, 1901; *Cymbephallus fimbriatus* Linton, 1934; *Fimbriatus fimbriatus* (Linton, 1934) Von Wicklen, 1946.

The metacercariae used in this study were first observed alive and then fixed in an alcohol-formalin-acetic acid solution (AFA). A few specimens were fixed under slight coverslip pressure; most were fixed without flattening in hot AFA so the acetabulum would be fixed in an extended position. The whole mounts were stained in Semichon's acetocarmine or Ehrlich's acid hematoxylin. Serial frontal sections were cut at ten microns and stained with Ehrlich's acid hematoxylin and eosin. All measurements of metacercariae (30 encysted, 30 excysted) were taken from living specimens; those of adults are from Linton's work (1934, 1942).

The cyst wall is thin, clear, about 1.7 microns thick and easily broken by active metacercariae. The size and shape of the cysts depends on the age of infection; the young cysts are almost spherical, the older ones almost sausage shaped. In the more mature cyst the worm is usually folded on itself. The average size of the cysts is about 0.68 by 0.25, the more mature cysts attaining 1.2 by 0.5. Worms removed from cysts average 0.84 by 0.3, the larger ones attaining 1.9 by 0.48. The morphology (fig. 23) is very similar to that of the adult except that the metacercariae apparently do not become sexually mature while encysted.

Of 137 *P. duorarum* from Apalachicola Bay, Alligator Harbor and near the mouth of the St. Marks River every one was infected with this metacercaria. In contrast, none of 120 specimens of *P. setiferus* and 36 of *P. aztecus* from Apalachicola Bay were infected with this parasite. The three species of shrimp live closely associated in the same habitat and have been collected together in a single trawl haul. All three shrimp species are undoubtedly exposed to the cercariae of *O. fimbriatus,* yet in the present work, only *P. duorarum* has been found infected. Hutton *et al* (1959) found a single specimen of *O. fimbriatus* in *P. setiferus* from Apalachicola Bay and Woodburn *et al* (1957) reported *Trachypeneus* sp. as a host in southwest Florida. For a discussion of the hosts and distribution of metacercariae and adults of this trematode the reader is referred to papers by Linton (1901, 1905, 1940), Woodburn *et al* (1957), Sparks (1958), Hutton *et al* (1959) and Sogandares-Bernal and Hutton (1959).

The metacercariae were found in all stages of development in young and old shrimp indicating that the shrimp are being continually infected in the bays or the shallow coastal waters. There is some correlation between the number of encysted metacercariae and age (determined by the size) of the shrimp. Table 1 is an accurate record of the number of these parasites recovered from 75 shrimp examined from June through September. The data indicate an increase in the number of metacercariae per host as the shrimp increases in size. Other data in this author's possession suggest what appears to be an increase in the number of metacercariae in shrimp of the same size range as the season progresses from spring to fall.

All details of anatomy are not visible in the immature specimens. For this reason as well as to be reasonably certain of the indentification of this metacercaria, the writer examined the adult type specimens. (U. S. National Museum No. 8266) from which Linton (1934) described *Cymbephallus fimbriatus.* This study revealed certain errors in Linton's description. His specimens were not as favorable for morphological studies as some in the writer's collection. The species is therefore redescribed from the type specimens and from whole mounts and serial sections of metacercariae obtained in the present work. Data are also included from Linton (1934, 1942) and Hopkins (1941).

Opecoeloides fimbriatus (Linton, 1934)
Sogandares-Bernal and Hutton

Description. — Body elongate, broadly rounded posteriorly, 1.28 to 4.62 long by 0.60 to 0.84 wide. Oral sucker well developed, 0.12 to 0.26 in diameter, located on antero-ventral extremity. Ventral sucker larger than oral, 0.21 to 0.35 in diameter, pedunculated, surrounded by raised border made up of four lobes each having from five to nine papillae; main body of sucker protruding as two prominent papillae at the junction of the four lobes. Small accessory sucker with limiting membrane, anterior to ventral sucker, 0.08 to 0.04 in diameter. Pharynx broadly ovate, 0.09 by 0.14; esophagus longer than pharynx; intestinal ceca extending to the posterior end and emptying separately into the excretory vesicle or opening separately to outside depending upon the contraction of the body. Genital atrium common, muscular, genital pore immediately in front of accessory sucker. Testes two, tandem, usually lobed, post-equatorial; sperm ducts long, uniting at seminal vesicle, 1/3 to 1/2 the distance from ovary to bifurcation of gut. Seminal vesicle composed of short bulbous posterior portion and narrow, elongate anterior portion which connects to muscular cirrus. Ovary anterior to fore-testis, usually not lobed; oötype and Mehlis' gland slightly anterior to ovary;

TABLE 1.
Intensity of parasitism by Opecoeloides fimbriatus in Penaeus duorarum of various sizes

Size Range of Shrimp in mm	Number of Infected Shrimp Examined	Number of Parasites Per Shrimp	
		Average	Range
10-19	1	2	2
20-29	6	2.3	1-3
30-39	13	4	1-8
40-49	19	7.8	1-26
50-59	10	10.6	4-21
60-69	10	10.5	4-14
70-79	9	12.7	4-30
80-89	3	15	12-20
90-99	3	31	14-37
100-109	1	97	97

uterus moderately folded, lying mostly in direct line between ovary and genital pore; eggs about 0.06 by 0.03. Vitelline reservoir at the dorsal, anterior border of the ovary; vitellaria filling the body posterior to the testes; extending laterally along the margins to a point about half-way between the ovary and ventral sucker. Excretory vesicle a long sac-shaped structure that extends anteriorly to anterior border of first testis, with two main collecting tubules emptying into the antero-lateral corners.

Hosts.—Adults in *Menticirrhus saxatilis, M. americanus, Bairdiella chrysura, Micropogon undulatus* and *Sciaenops ocellata.* Metacercariae in *Penaeus duorarum, P. setiferus* and *Trachypeneus constrictus.*

Location.—Adults in intestine, metacercariae in coverings and other tissues surrounding the digestive gland, stomach, heart, gonads, and intestine; also in tissue of the head region and tissues next to the lateral and dorso-lateral portions of carapace.

Number. — Average number of metacercarial cysts per shrimp: 10; range: 2 to 97.

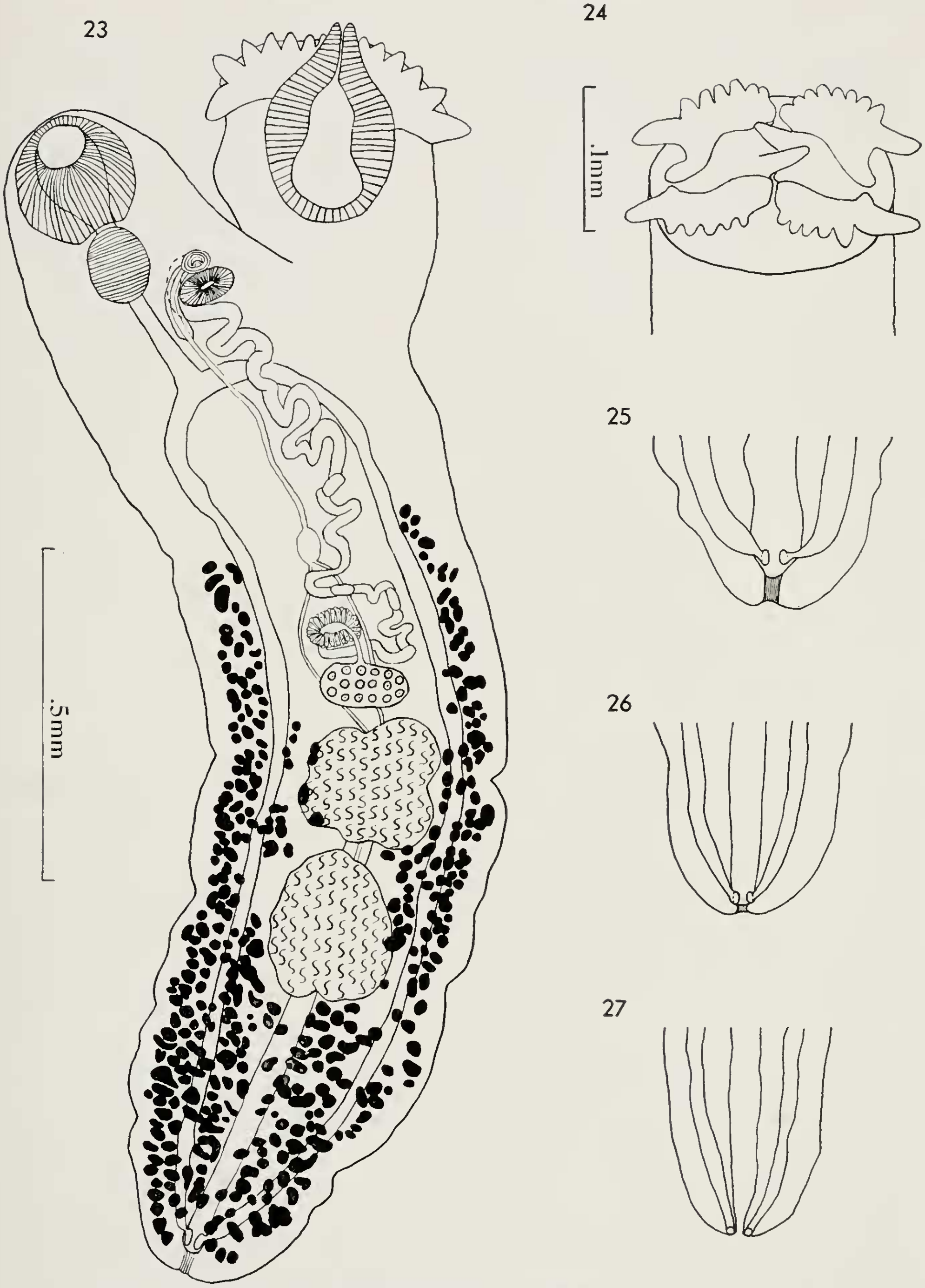
Locality.—Atlantic and Gulf Coasts of United States.

The writer's description differs from Linton's (1934) in the following ways: (1) A more complete description is given of the ventral sucker which in Linton's type specimens was retracted; (2) The ceca are described as emptying separately into the excretory vesicle which empties to the outside rather than ending blindly as Linton described; (3) A description is given of the excretory vesicle which Linton omitted and which agrees with the description by Hopkins (1941) of the same species; (4) The ejaculatory duct is described as opening into a common genital atrium along with the uterus rather than opening through the accessory sucker as Linton described.

The fact that this trematode has an accessory sucker, ceca which empty into the excretory vesicle, a pedunculated acetabulum with papillae and no cirrus pouch places it in the genus *Opecoeloides* Odhner, 1928. Von Wicklen (1946) reported that each cecum opened separately to the outside. Consequently she established a new genus for this trematode, giving it the name *Fimbriatus fimbriatus.* In the type specimens examined by the writer the vitellaria obscured the posterior ends of the ceca. Frontal sections and mounts of metacercaria showed that the ceca empty into the excretory vesicle.

Sogandares-Bernal and Hutton (1959) observed that the posterior tips of the ceca moved to positions where each cecum and the bladder emptied separately to the outside when the metacercaria was extended and then returned to the normal position of emptying into the excretory vesicle, when the worm contracted. The writer also observed this phenomenon (figs. 25-27) and saw particles pass from the ceca to the excretory vesicle and then to the outside when the worm contracted, and directly to the outside when extended. The writer fixed a group of 55 metacercariae with a considerable amount of coverslip pressure. One of the 55 was fixed in the extended position with the ceca emptying separately to the outside and several were fixed in intermediate positions. A specimen fixed in a flattened and extended position with the ceca emptying directly to the outside could account for a description of this species as having two ani; however, the writer did not observe this condition in the type specimens.

The remaining life cycle stages for *Opecoeloides fimbriatus* are not known. Opecoelid cercariae possess a stylet, lack eyespots and body spines, have a short glandular tail, possess a thick-walled excretory vesicle that has a very uneven lumen due to protrusion of large wall cells into it, have a 2 [(2 + 2) + (2 + 2)] excretory formula, and develop within sporocysts in prosobranch snails (Cable 1956a, 1956b). The life cycle of *Anisoporus manteri* Hunninen and Cable, 1940, which Von Wicklen (1946) synonymized with *Opecoeloides vitellosus* (Linton, 1900) has been worked out by Hunninen and Cable (1941) and is probably similar to the life cycle of *O. fimbriatus.* The adult of *O. vitellosus* has been reported in over 60 species of marine fishes (Linton, 1934; Hunninen and Cable, 1940); however, Von Wicklen (1946) stated that some of the trematodes identified as *O. vitellosus* are other species. The cercaria of *O. vitellosus* occurs in the marine gastropod *Mitrella lunata* (Say) and the metacercaria in the marine amphipods, *Carinogammarus mucronatus* (Say) and *Amphithoe longimana* Smith.



Figures 23-27. Metacercaria of *Opecoeloides fimbriatus* (Linton) Sogandares-Bernal and Hutton. All illustrations from preserved specimens. **23**. Excysted matacercaria. **24**. Schematic drawing showing morphology of acetabulum, oblique view of surface. **25-27**. Stages of contraction and extension of metacercaria showing change in position of cecal openings. **25**. Contracted position with cecal openings emptying into excretory vesicle. **26**. Intermediate position. **27**. Extended position with ceca and excretory vesicle opening separately to the outside.

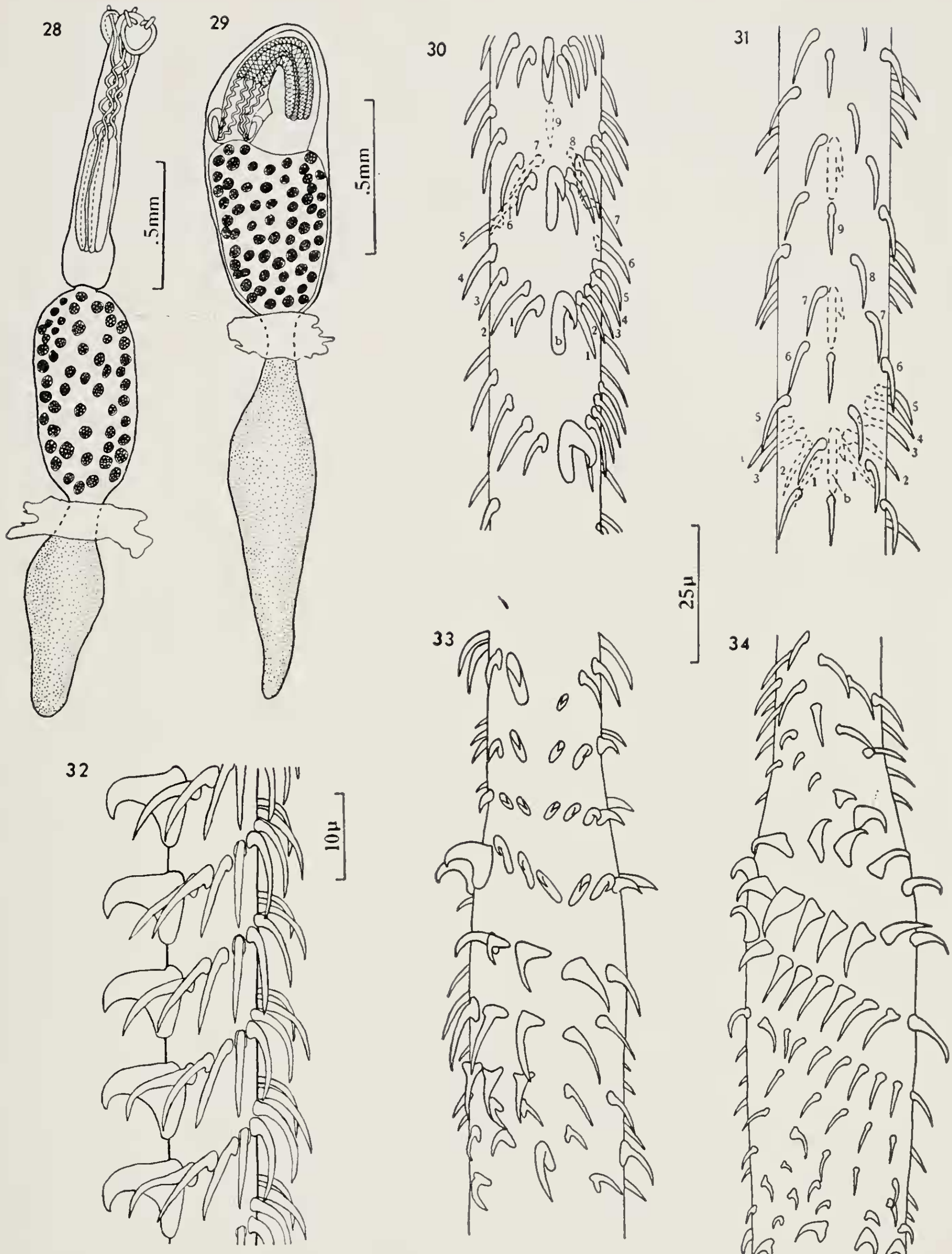
Class Cestoidea Rudolphi, 1809
Order Trypanorhyncha Diesing, 1863
Family Eutetrarhynchidae Guiart, 1927
Prochristianella **penaei**, sp. nov.
(Figures 28-34)

Most of the observations and illustrations recorded herein were made from live plerocerci. The live specimens showed the arrangement of hooks, bulbs, tentacles, and details of the excretory system much better than preserved material. A small needle was used to break the cyst wall and to free the holdfast end of the body. Protrusion of the tentacles for study of hook arrangement was accomplished by exerting slight cover glass pressure on living specimens or by relaxing the specimens in saline solution at 4° C overnight. Some larvae were fixed in AFA and stained with Semichon's acetocarmine or Ehrlich's acid hematoxylin. The measurements are based on 20 worms taken from the three species of shrimp collected at various times during the summer and fall. All hook measurements were made near the middle of the tentacle.

Description. — Encysted plerocerci cylindrical, 1.1 (0.62-2.30) long by 0.52 (0.33-1.03) wide; cyst wall clear, thin, 1.8 microns thick; holdfast region not withdrawn into blastocyst, surrounded only by cyst wall. Excysted pleroceri 1.8 (0.82-3.29) long by 0.46 (0.21-0.68) wide; holdfast region 0.82 (0.39-1.24) long by 0.15 (0.12-0.19) wide; blastocyst 1.0 (0.39-2.27) long by 0.46 (0.21-0.68) wide. Bothridia two, patelliform; bothridial surfaces parallel to holdfast region with posterior margins free, not notched, 0.15 (0.12-0.17) long. Bulbs four, 0.44 (0.37-0.56) long by 0.04 (0.03-0.05) wide with mass of red granules at anterior end of each bulb. Proximal part of sheath sinuous. 0.40 (0.27-0.64) long; tentacles 0.60 (0.48-0.74) long by 0.02 (0.015-0.03) wide at mid-point, covered with hooks. Hook arrangement heterocanthous, heteromorphous; metabasal armature composed of a single longitudinal row of large, stout hooks on internal surface of each tentacle and a series of obliquely ascending, half-turn spiral rows of smaller hooks that start on internal surface and continue distally around bothridial and antibothridial surfaces until they meet on external surface; last few hooks of each half-turn spiral row meet on the external surface in an off-set inverted V where the hook of one ascending row meets the opposite row between the last and next to last hooks. Large basal hooks about 10 microns long, with base about 8.5 microns long, short toe, long heel and recurved point; smaller hooks long, slender, spinous, and diminishing in size as they pass to external surface; usually seven to nine hooks in each ascending row. Hooks in each row becoming fewer, closer together and smaller toward distal end of tentacle; toward base of tentacle hooks in each row becoming more numerous, farther apart and larger, but the same basic arrangement persisting except at base. Proximal or basal portion of tentacle swollen with special arrangement of hooks: few, large, recurved hooks; many rows of long, slender, spinous hooks. Tentacles protruding through openings in antero-lateral corners of external surfaces of bothridia. Postbulbosal region

TABLE 2.
Incidence of infection of shrimp by the plerocercus of Prochristianella penaei

	P. aztecus	*P. duorarum*	*P. setiferus*
Number of Shrimp Examined	128	137	36
Number of Shrimp Infected	116	132	34
Percentage of Shrimp Infected	90.6	97	94.4
Average Number of Parasites per Shrimp	6.2	7.0	14.7
Range of Number of Parasites per Shrimp	0-42	0-37	0-26
Average Size of Shrimp Examined	110.4 mm	52.4 mm	114.7 mm



Figures 28-34. Plerocercus of *Prochristianella penaei*, sp. nov. **28**. Excysted plerocercus. **29**. Encysted plerocercus. 30-34. Portions of tentacles showing arrangement and morphology of hooks. **30**. Metabasal armature of internal surface showing ascending, oblique, half-turn spiral rows; numbers 1-9 represent one bothrial row, numbers 1-7 the opposite row; b is the large, recurved, basal hook. **31**. Same as fig. 30, external surface. **32**. Side view of metabasal armature drawn from a preserved specimen showing that preservation shrinks the tentacle, drawing the hooks closer together. **33**. Armature of internal surface of basal swelling. **34**. Armature of external surface of basal swelling.

(between bulbs and blastocyst) short. Blastocyst muscular, divided into two regions by constriction; anterior portion filled with numerous, dark, granular bodies, 50 microns in diameter; posterior portion filled with small homogeneous granules. Blastocyst usually attached to host tissue or another cyst at constriction.

Hosts.—Plerocerci in *Penaeus aztecus*, *P. duorarum* and *P. setiferus*.

Location. — Digestive gland and tissues surrounding digestive gland and stomach, blastocysts of larvae frequently penetrating wall of digestive gland.

Locality.—Northern Gulf coast of Florida.

Types.—Holotype will be deposited in the U. S. N. M. Helminthological Collection; paratypes in the Helminthological Collection of the Department of Biological Sciences, Florida State University.

Table 2 presents data on incidence of infection. The writer examined 301 shrimp for this cestode and found 282 or 93.6 percent infected with a high incidence in all three host species. The average number of parasites per shrimp was 8.1, and the range was 0 to 42. This trypanorhynchan larva was found in shrimp collected from each of the three collections areas, Alligator Harbor, near the mouth of the St. Marks River, and Apalachicola Bay.

Table 3 presents data indicating an increase in the number of plerocerci as the age (indicated by size) of the shrimp increases. This is probably due to two reasons; first, the shrimp are being infected continually, thus building up the infection; second, the larger shrimp are usually collected during the fall when a higher rate of infection may be taking place. The second explanation is supported by data from shrimp of the same species and same size range in the early summer and late fall. Shrimp in the fall show a considerable increase in the average number of parasites per individual over those collected in early summer. However,

TABLE 3.
Intensity of parasitism by Prochristianella penaei in shrimp of various sizes

Species	Size Range of Shrimp in mm	Number of Infected Shrimp	Number of Parasites Per Shrimp	
			Averages	Ranges
P. aztecus				
	60-69	1	7	—
	70-79	1	6	—
	80-89	8	6	4-12
	90-99	14	5.3	2-17
	100-109	18	5.6	1-11
	110-119	24	6.7	1-31
	120-129	11	9	3-42
	130-139	7	6	1-23
	140-149	2	5.5	2-9
	150-159	1	8	—
P. duorarum				
	10-19	1	3	—
	20-29	6	2.6	1-4
	30-39	13	3.1	1-7
	40-49	16	2.9	1-17
	50-59	10	5.2	4-18
	60-69	11	6.6	4-14
	70-79	9	6.5	3-21
	80-89	3	16.3	12-20
	90-99	3	22.3	14-37
	100-109	1	20	—
P. setiferus				
	60-69	2	9	6-12
	70-79	2	6.5	3-10
	80-89	1	8	—
	90-99	2	5	4-6
	100-109	2	10	8-12
	110-119	4	19.2	17-24
	120-129	6	13.3	4-26
	130-139	3	18.3	17-21
	140-149	2	11	8-14

P. aztecus, which live in the bay and shallow coastal waters mainly during the late spring and early summer, have a lower percentage and lighter intensity of infetcion than *P. duorarum* and *P. setiferus,* which live in the bay and shallow coastal waters mainly during late summer and fall (Table 2). Possible explanations of this difference are a higher resistance in *P. aztecus* than in the other two species or more mature procercoids and first intermediate hosts during the late summer and fall.

Woodburn *et al* (1937), Sparks and Mackin (1957), and Hutton *et al* (1959) give accounts of the known hosts and distribution of this cestode.

The genus *Prochristianella* was established by Dollfus (1946) to accommodate species in the family Eutetrarhynchidae which have a basal tentacular swelling and either heteromorphic or hemoeomorphic armature. He included two species in the genus, the type species *P. trygonicola* Dollfus, 1946 [adults from spiral valve of *Dasyatis pastinaca* (L) and plerocercus from the digestive gland of *Upogebia stellata* (Montagu)] and *Rhynchobothrium tenuispine* Linton, 1890 [adults from *Dasyatis centroura* (Mitchill)]. *P. penaei* differs considerably from *P. trygonicola* and *P. tenuispinis* (Linton 1890) in arrangement and morphology of hooks. The row of large, recurved hooks in *P. penaei* is lacking in the other two species; the metabasal armature of *P. tenuispinis* is completely homeomorphic; and in *P. trygonicola* each half-turn spiral rows starts with short slender hooks on the internal surface, the hooks becoming long and slender on the bothridial and antibothridial surfaces and then becoming short and slender again on the external surface.

Although no complete life cycle has been elucidated in the Order Trypanorhyncha, adults are known to occur in the spiral valve of selachians. The work of Ruzkowski (1932, 1934) (*fide* Dollfus, 1942) as well as other bits of evidence, indicate the following course of events: the eggs are released into the sea when the selachian defecates, a free-swimming coracidium hatches from the egg; the coracidium is eaten by the first intermediate host (copepod) and then develops into a procercoid; the procercoid is eaten, along with the first intermediate host, by a second intermediate host (fish, mollusk, or decapod) in which the procercoid develops into a plerocercus; the plerocercus is eaten, along with the second intermediate host, by a selachian; the plerocercus then develops into an adult in the selachian.

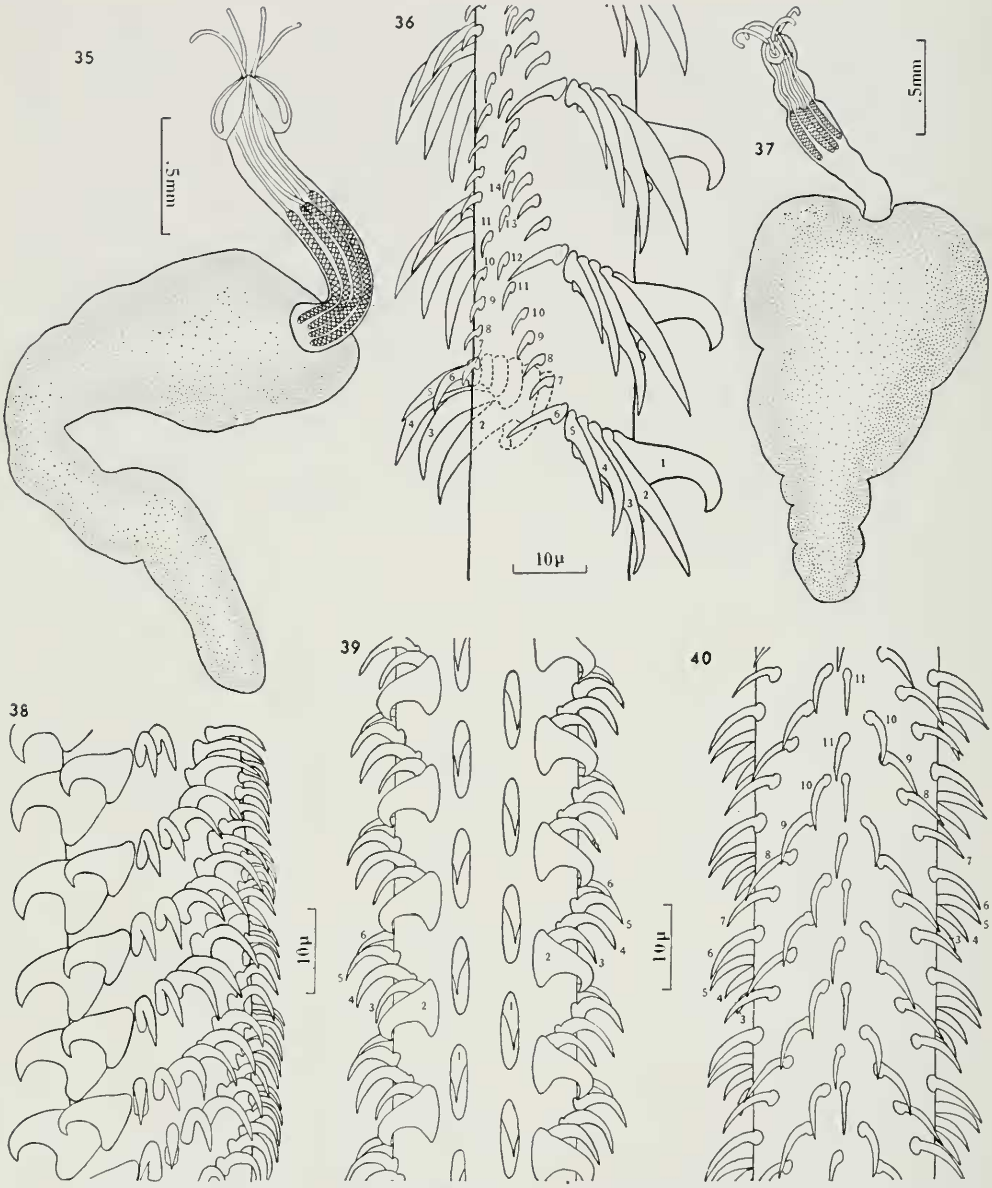
The writer autopsied three specimens of *Dasyatis sabina* (LeSueur), two of *Rhinoptera bonasus* (Mitchill) and one of *Raja texana* Chandler, all of which feed extensively on shrimp. Their stomachs were crowded with shrimp that still contained live plerocerci; however, no adult *Prochristianella penaei* were found in their intestines. Examination of shrimp stomachs for parasites frequently revealed what appeared to be remnants of copepods, amphipods, and ostracods, crustaceans which could very possibly serve as first intermediate hosts for *P. penaei.*

Parachristianella **monomegacantha,** sp. nov.

(Figures 35, 36)

The plerocerci were first studied alive and then fixed in AFA and stained in Semichon's acetocarmine. Protrusion of the tentacles was accomplished by exerting slight cover glass pressure. Only two specimens were recovered, both from *P. duorarum.* One was accidentally destroyed, therefore, all measurements were taken from the remaining specimen. The holdfast regions of both specimens were free and active by the time the parasites were recovered; therefore, no information is available on the nature of the encysted plerocercus. A total of 301 shrimp was examined, 137 of which were *P. duorarum.*

Description. — Plerocercus large, stout 3.82 long; body divided into distinct anterior holdfast portion and posterior blastocyst region; holdfast sub-cylindrical, 1.13 long by 0.198 wide; bothridia two, patelliform, 0.128 long, slanted toward mid-point anteriorly but not confluent, posterior margins not free. Bulbs four, 0.56 long by 0.03 wide; with mass of red granules at anterior end of each bulb; sheath 0.46 long; tentacles protruding at antero-lateral corners of external surface of bothridia, 0.77 long by 0.028 wide at mid-point; armed with hooks which are heterocanthous and heteromorphous. Metabasal armature a sequence of oblique, ascending, half-turn spiral rows of



Figures 35-40. 35-36. *P. monomegacantha*, sp. nov. **35**. Excysted plerocercus. **36**. Metabasal armature of tentacle; hooks numbered 1-14 represent one ascending, oblique, half-turn spiral row and 1-11 the opposite row. 37-40. *P. dimegacantha*, sp. nov. **37**. Excysted plerocercus. **38**. Side view of tentacle from preserved specimen. **39**. Metabasal armature of internal surface; hooks numbered 1-6 represent proximal portion of half-turn spiral row; hooks 1 and 2 are large, basal, recurved hooks. **40**. Metabasal armature of external surface; hooks numbered 3-11 represent distal portion of half-turn spiral row.

hooks which start on internal surface of tentacle and cross to external surface alternately around the bothridial and antibothridial surface; last hooks of each half-turn spiral making an off-set inverted V on external surface where the last hook of one ascending spiral row ends at a level slightly below the second from last hook of the opposite spiral row. First hook of each half-turn spiral large, about 19 microns long, with base about 14 microns long, short toe, long heel and a recurved point; these first hooks arranged in two alternate rows on internal surface; other hooks very long, slender and spiny; hooks gradually diminishing in size as they pass to external surface, usually about 11 to 14 hooks in each half turn spiral at mid-region of tentacle. Same arrangement of hooks persisting for entire metabasal armature; toward base of the tentacle the hooks in each row becoming large, more numerous and farther apart; toward the distal end the hooks in each row becoming smaller, fewer and closer together. Base of tentacle not swollen, basal armature reduced, consisting of a few small, slender hooks. Postbulbosal region very short, 0.112 long; blastocyst large, granular, muscular, 2.8 long by 0.70 wide at widest portion near anterior end.

Host.—Plerocercus in *Penaeus duorarum.*

Location.—In digestive gland, with blastocyst protruding through wall of digestive gland.

Locality.—Northern Gulf coast of Florida.

Type.—Holotype in author's collection.

Dollfus (1946) established the genus *Parachristianella* to include the species in the family Eutetrarhynchidae Guiart, 1927 that have heteromorphic metabasal armature and no basal swelling of the tentacle. The only species he placed in the genus was the type species *P. trygonis* from the spiral valve of *Dasyatis pastinaca* (Linnaeus) from Concarneau, France. *P. monomegacantha* is the second species and strengthens the validity of the genus. The plerocercus of *P. trygonis* was described (Dollfus, 1946) from *Upogebia stellata* (Montagu) collected in Arcachon, France.

P. monomegacantha differs from *P. trygonis* in the following points: (1) *P. monomegacantha* has two rows of large, recurved hooks with long bases on the internal surface of the tentacle whereas *P. trygonis* has four rows of such hooks; (2) The posterior margins of the bothridia are not as free in *P. monomegacantha* and the bothridia are more closely approximated anteriorly than in *P. trygonis;* (3) The blastocyst in *P. monomegacantha* is not as well differentiated into anterior and posterior regions as in *P. trygonis;* (4) The overall size of the plerocercus of *P. trygonis* is greater than that of *P. monomegacantha;* (5) The intermediate and the definitive hosts are different; however, the extremely low incidence of infection in shrimp with *P. monomegacantha* indicates that shrimp may not be the only, or even the usual, intermediate host for this species.

Parachristianella **dimegacantha,** sp. nov.
(Figures 37-40)

One specimen of P. *dimegacantha* was recovered; it was first studied alive, then fixed in AFA and stained with Semichon's acetocarmine. Protrusion of the tentacles was accomplished by placing the larva in saline solution at 4° C for 24 hours. All measurements were made from this individual.

P. dimegacantha was recovered from *P. duorarum.* A total of 301 shrimps was examined, 137 of which were *P. duorarum.* The holdfast was free and active when the specimen was recovered; therefore, no information is available on the encysted stage.

Description. — Plerocerus large, stout, 3.28 long; body divided into distinct anterior holdfast region and posterior blastocyst region; holdfast sub-cylindrical, 1.05 long by 0.211 wide. Bothridia two, small, patelliform, 0.132 long, slanted toward midpoint anteriorly but not confluent, posterior edges not free; bulbs shorter than sheath or postbulbosal region, 0.297 long by 0.039 wide; mass of red granules at anterior end of each bulb; sheaths slightly sinous, 0.326 long. Tentacles protruding at antero-lateral borders of external surface of bothridia, 0.389 long by 0.021 wide at mid-point, armed with hooks. Hook arrangement heterocanthus, heteromorphic; metabasal armature a series of obliquely ascending, half-turn spiral rows that start on the internal surface and pass alternatively across the bothridial and antibothrial surfaces to the external surface; last hooks of each half-turn spiral meeting on the external surface in an off-set inverted V where the last hook of one ascending row meets the opposite row between the last and next to the last hooks. The first two hooks of each ascending row about 14 and 10 microns long respectively, with bases about 9 and 7 microns long, with short toes, long heels and recurved points; these first hooks arranged in two alternate rows. Other hooks long, slender, spinous, and diminishing in size as they pass to external surface; usually 9 to 12 hooks in each half-turn spiral at middle of tentacle. Same arrangement of hooks persists for entire metabasal armature; toward base of tentacle hooks in each row becoming larger, more numerous and farther apart; toward the distal end hooks in each row becoming smaller, fewer and closer together. Base of tentacle not swollen, basal armature reduced, consisting of a few small, slender hooks. Postbulbosal region relatively long, 0.415; blastocyst large, granular, muscular, 2.21 long by 1.37 wide at widest portion near anterior end.

Host.—Plerocercus in *Penaeus duorarum.*

Location. — In digestive gland, part of blastocyst protruding through wall of digestive gland.

Locality.—Alligator Harbor ,Florida.

Type.—Holotype in writer's collection.

P. dimegacantha is the third species in the genus and differs from the plerocercus of *P. trygonis* in the following points: (1) *P. dimegacantha* has fewer hooks in each ascending half-turn spiral row; the rows are arranged differently and meet on the external surface in a different manner; (2) The bulbs of *P. dimegacantha* are less than a third of the length of the holdfast, whereas in *P. trygonis* they are almost one half the length of the holdfast; (3) The bothridia of *P. dimegacantha* are closer together at the anterior end and the posterior margins are not as free; (4) The postbulbosal region is longer in *P. dimegacantha;* however, this distance may not be constant; (5) The blastocyst of *P. dimegacantha* is not sharply divided into an anterior and posterior region as in *P. trygonis;* (6) The over-all size of the plerocercus of *P. trygonis* is much larger than that of *P. dimegacantha;* (7) The intermediate and definitive hosts are different; however, the extremely low incidence of infection in shrimp with *P. dimegacantha* indicates that shrimp may not be the only, or even the usual, intermediate host for this species.

P. dimegacantha and *P. monomegacantha* (described above) differ considerably in hook arrangement (figs. 36, 38-40) and in the relative sizes of the bothridia, bulbs, and postbulbosal regions.

Cestode Larva

The specimens were observed alive and then stained with Semichon's acetocarmine and mounted in Damar for further study. All measurements were taken from 20 preserved specimens; other details of the following description are from living specimens.

Description.—Small, solid, pyriform, larva; body 0.125 (0.112-0.132) long by 0.066 (0.052-0.085) wide. Well developed apical sucker, 0.033 (0.026-0.029) long, by 0.046 (0.039-0.052) wide. Four well developed glands immediately posterior to apical sucker, each with a separate duct leading forward, passing through sucker wall and emptying into sucker cavity. Small sac-like osmoregulatory bladder near posterior end of body emptying to outside through prominent pore; flame cells and excretory tubules asymmetrical in arrangement, three flame cells maximum number seen in one individual. Body cuticle covered with closely arranged rows of very fine spines. Thirteen to 19 large calcareous corpuscles scattered throughout body; rest of body filled with smaller homogeneous granules.

Hosts.—*Penaeus aztecus* and *P. duorarum.*

Location.—Internal lining of mid-intestine.

Locality.—Alligator Harbor and Apalachicola Bay, Florida.

Number.—27 (14.3 percent) of the 188 shrimp examined were infected with this parasite. Twenty-one (16.4 percent) of the 128 *P. aztecus* and six (10 percent) of the 60 *P. duorarum* harbored this cestode. From 27 to 122 of these parasites were found in every infected shrimp.

Lack of specific structures rendered further identification of this larva uncertain. According to Wardle and McLeod (1952), larval forms of this type have been reported from other marine invertebrates such as pearl oysters, other lamellibranchs, and medusae; they have also been recorded from fishes. None of these larvae have been correlated with an adult. Hutton *et al* (1959) tentatively referred what appears to be the same larva to the Lecanicephala.

Class Nematoda (Rudolphi, 1809) Cobb, 1919

Order Rhabditida Chitwood, 1933

Family Ascarididae Blanchard, 1896

Juvenile of *Contracaecum* sp.

(Figures 21, 22)

These juvenile nematodes were studied alive and then fixed in hot ten percent formalin for further study. All measurements are based on ten preserved specimens, four specimens each from *Penaeus duorarum* and *P. aztecus*, and two from *P. setiferus*.

Description. — Body slender, tapering gradually anteriorly and more abruptly posteriorly, 1.74 (1.32-2.44) long by 0.08 (0.06-0.10) wide at widest portion near middle. Cuticle finely annulated, annulations 5 to 9 microns wide. Lips three, about equal in size, 0.020 (0.016-0.023) long by 0.015 (0.014-0.018) wide, (dorsal lip often slightly shorter than ventro-lateral lips); large cuticular boring tooth on one ventro-lateral lip. Esophagus muscular 0.396 (0.315-0.462) long by 0.029 (0.028-0.030) wide at mid-point, no distinct bulb, enlarged slightly posteriorly, ventriculus 0.029 (0.021-0.035) long by 0.029 (0.022-0.037) wide; ventricular diverticulum well developed, 0.277 (0.169-0.315) long by 0.028 (0.016-0.035) wide at mid-point. Intestine long, very thick walled, filling most of body cavity, 0.050 (0.042-0.065) wide at mid-point; intestinal diverticulum projecting anterior to ventriculus, 0.118 (0.107-0.126) long by 0.020 (0.014-0.029) wide at mid-point; the intestine narrowing abruptly posteriorly; well developed sphincter muscle separating intestine from short, narrow rectum; rectum provided with three pairs of well developed rectal glands, two pairs dorsal to rectum, one pair ventral; anus 0.098 (0.083-0.113) from posterior end. Nerve ring 0.112 to 0.161 from anterior end; excretory pore 0.130 to 0.190 from anterior end. Sex of individual juvenile nematodes could not be determined.

Hosts.—*Penaeus aztecus, P. duorarum* and *P. setiferus.*

Location.—In digestive gland and tissues surrounding digestive gland and stomach, not encysted.

Locality.—Alligator Harbor and Apalachicola Bay, Florida.

Specimens on deposit.—U. S. N. M. Helminthological Collection No. 37269.

The writer examined 255 shrimps collected from June to November, 1958, for nematodes and found 14 parasitized with an average of 3.1 per host. Table 4 gives data on the parasitism in each species of shrimp.

Juveniles of the genus *Contracaecum* Railliet and Henry, 1912 have been found in fishes and a variety of invertebrates such as medusae, *Sagitta,* copepods, amphipods, and cephalopods (Hyman, 1951). The adults are typically parasites of the digestive tract of fishes, fish-eating birds, and mammals. To the writer's knowledge there is only one record of an adult *Contracaecum* sp. infecting a prawn, *Pandalus borealis* Kroyer, and this was from the coast of British Columbia, Canada (Margolis and Butler, 1954). These authors concluded that the prawn was an abnormal definitive host and tentatively identified the nematode as *Contracaecum aduncum* (Rudolphi, 1802).

Woodburn *et al* (1957) reported nematodes in *P. duorarum* from the Tortugas region and in a "white shrimp" from Apalachicola Bay, but did not identify them further. Hutton *et al* (1959) identified a nematode of the genus *Contracaecum* in *P. duorarum* from southwest Florida.

SUMMARY

1. A total of 301 shrimps of the species *Penaeus aztecus, P. duorarum* and *P. setiferus* was examined for parasites. These were collected from Apalachicola Bay, Alligator Harbor and near the mouth of the St. Marks River, Florida during the summer and fall of 1958.

2. *Cephalolobus penaeus,* gen. nov., sp.

TABLE 4.
Incidence of parasitism in shrimp by juveniles of Contracaecum sp.

	P. aztecus	*P. duorarum*	*P. setiferus*
Number of Shrimp Examined	128	91	36
Number of Shrimp Infected	3(2.3%)	9(9.7%)	2(5.5%)
Average Number of Parasites per Shrimp	4	1.7	4
Range of Number of Parasites per Shrimp	1-10	1-3	2-6

nov. (Eugregarinida Dolfein) is described from *Penaeus aztecus* and *P. duorarum*. It was found attached to a thin, chitinous sheet in the stomach of 17.7 percent of the *P. aztecus* (average of 1.7 parasites per host) and 20.8 percent of the *P. duorarum* (average of 4.5 parasites per host). This species differs from most cephaline gregarines by the absence of a true epimerite; the anterior end of the protomerite is modified into a lobed holdfast.

3. *Nematopsis penaeus* Sprague, 1954 (Eugregarinida Doflein) is reported from *Penaeus aztecus*, *P. duorarum* and *P. setiferus*. Every shrimp examined was found to harbor at least one stage of this gregarine; the young trophozoites were attached to the gut cells, the sporonts were free in the gut and the gametocysts were encysted on the wall of the rectum. Additional details of morphology are added to Sprague's description.

4. A microsporidian of the genus *Thelohania* is described from the musculature of *Penaeus aztecus, P. duorarum* and *P. setiferus*. Of the 4816 shrimp examined, 553 (11 percent) were grossly identified as "cotton shrimp". The microsporidian apparently is not *T. penaei* Sprague, 1950 reported from *P. setiferus;* comparison with *T. hunterae* Jones, 1958 and *T. duorara* Inversen and Manning (in press) must be made before specific identification.

5. The metacercaria of the trematode *Opecoeloides fimbriatus* (Linton, 1934) Sogandares-Bernal and Hutton is reported and described from the pink shrimp, *Penaeus duorarum*. This parasite was found encysted in the tissue surrounding the digestive gland and stomach. *Penaeus duorarum* was the only shrimp that harbored this trematode, and all specimens examined were positive. The average number of parasites per shrimp was ten, with a higher average number during the fall than during the summer. *O. fimbriatus* is redescribed from the type specimens and from new information obtained during the study of the metacercariae.

6. *Prochristianella penaei* is described as a new species of Trypanorhyncha from plerocerci found in the digestive gland of *Penaeus aztecus, P. duorarum* and *P. setiferus*. The plerocerci were found in 93.6 percent of the shrimp with an average of 8.1 per host. The number of parasites per shrimp increased with the age of the host and toward the fall of the year. *P. penaei* differs from the other two species in the genus, *P. trygonicola* Dollfus, 1946 and *P. tenuispinis* (Linton, 1890), chiefly in the arrangement and structure of hooks of the metabasal armature of the tentacles.

7. *Parachristianella monomegacantha* and *Parachristianella dimegacantha* are described as new species of Trypanorhyncha from plerocerci recovered from the digestive gland of *P. duorarum*. Only two specimens of *P. monomegacantha* and one of *P. dimegacantha* were found in 137 *P. duorarum*. The two species differ considerably from each other and from *P. trygonis* Dollfus, 1946 (the only other species in the genus) in the arrangement and structure of hooks of the metabasal armature of the tentacles.

8. A small unidentified cestode larva from the intestinal lining of *Penaeus aztecus* and *P. duorarum* is reported. From 27 to 122 of these parasites were found in the infected shrimp; 14.3 percent of the hosts examined were infected.

9. An immature nematode in the genus *Contracaecum* is reported from *Penaeus aztecus, P. duorarum* and *P. setiferus*. This parasite was found in the digestive gland and tissues surrounding the stomach of 5.4 percent of the shrimp examined with an average of 3.1 per host.

Acknowledgements

The writer wishes to thank his major professor, Dr. Robert B. Short, for his unselfish aid and many helpful criticisms during the course of this work. The writer also thanks Mr. Robert M. Ingle of the Florida State Board of Conservation for suggesting a study of the parasites of shrimp and for aid in collecting specimens. Dr. Franklin Sogandares-Bernal, Department of Zoology, Tulane University, offered several helpful suggestions. Mr. Allen McIntosh, Dr. M. B. Chitwood of the Animal Disease and Parasite Research Branch, ABS, USDA, Beltsville, Md. and Dr. R. Ph. Dollfus of the Museum National D'Histoire Naturelle, Paris aided in identification of specimens.

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ABSTRACT

A total of 301 shrimp of the species *Penaeus aztecus*, *P. duorarum* and *P. setiferus* was examined for parasites. The shrimp were collected in the summer and fall of 1958 from the northwest Gulf coast of Florida. A new genus and species of gregarine, *Cephalolobus penaeus*, is described from *P. aztecus* and *P. duorarum*. It was found attached to a thin chitinous sheet between the filter and the base of the terminal lappets of the stomach. *Nematopsis penaeus* Sprague, 1954 is reported from all three species of shrimp and additional details of morphology are added to Sprague's description. Every shrimp examined harbored at least one stage of this gregarine; the young trophozoites were attached to the gut cells, the sporonts were free in the gut and gametocysts were encysted on the wall of the rectum. A microsporidian of the genus *Thelohania* is reported from the musculature of all three species of shrimp. The metacercaria of the trematode *Opecoeloides fimbriatus* (Linton, 1934) Sogandares-Bernal and Hutton is reported from the pink shrimp, *Penaeus duorarum*. These parasites were found encysted mainly in the tissue surrounding the digestive gland and stomach. This species is redescribed from type specimens and metacercariae. The Trypanorhyncha *Prochristianella penaei*, *Parachristianella monomegacantha* and *Parachristianella dimegacantha* are named and described from plerocerci recovered from the digestive gland. *P. penaei* from all three species of shrimp, *P. monomegacantha* and *P. dimegacantha* from *P. duorarum*. A small unidentified cestode larva is reported from the intestinal lining of *P. aztecus* and *P. duorarum*. Immature specimens of a nematode of the genus *Contracaecum* were found in the digestive gland and tissues surrounding the stomach of all three species of shrimp. The taxonomy, morphology, incidence, specificity and biology of each parasite is discussed.